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Understanding the Future Communication: 5G to 6G

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Abstract

This article enrolls the development and review of the 6G(6th Generation) wireless communication technology which is expected in the 2030s and is the first of its kind to review 6G concepts in IoT (Internet of Things). Wireless communication technology will make communication between entities and these technologies are separated as different generations. 6G wireless communication technology will be an application of IoT by bringing the world closer. 6G network implementation will be a promising and developing field in wireless communication technology. In this paper, we discuss how the 6th Generation of wireless communication technologies overcomes the existing problems faced by the previous generation (5G). We have a general architecture for wireless communication technology. By adding some new key concepts (Artificial Intelligence, optical wireless communication, terahertz frequency, and wireless power transfer) to this architecture we can produce a new generation (6G) of wireless technology. This paper also describes the advantages and challenges which can be faced by the 6th generation of wireless communication. A few of the key points trends behind the growth of the 6G wireless communications are green communication, network traffic, intelligent network, localization, new spectrums, high reliability, low latency, high data bit rate, network availability. The 6G will provide a better communication system in the future by ensuring future trends.

Keywords: *IoT, Artificial Intelligence, Terahertz frequency, Optical wireless communication and Wireless Power Transfer.*

1. Introduction

1.1 Wireless Communication

Wireless technology establishes a connection between two or more entities over some distance without any use of external cables or wires between those entities. The entities indicates any kind of electronic devices like mobile phones, laptops, desktops etc. variety of waves, frequencies and technologies are used to establish the connection between those entities. Wireless communication is the process of transferring some kind of information from one point to other points. Here the destination can be multiple points which are not physically connected. The distance between the

points can be short or so far. The distance and the technologies used between these points will be according to the evolution of the wireless communication. Wireless communication is derived as different generations. it extends from 0th Generation to 6th Generation. Every generation of the wireless communication improves their features and functions from their previous generations.

1.2 6th Generation of Wireless Communication

6G wireless communication technology will have a huge impact on smart technology. 6G will be fully connected and digital world. To overcome the challenges of previous generation (5th Generation) of wireless communication and ensuring more

facilities, a 6th Generation wireless system has to be developed with new attractive features. One of the major challenges of 5G is massive connectivity. The explosive growth in the number of users over a network is one of the reasons for data traffic. So to provide a massive connection we have to ensure more features than the 5G wireless communication through 6th Generation. Not only in massive connectivity has it provided improvements in speed, latency, network resilience and power consumption. The 6G (sixth generation) wireless communication aims to solve the substantially increased requirement of data rate and the avalanche of traffic volume. The 6G system would also continue the trends of 5G (previous generation), which also includes new services with the addition of new technologies. The new services or technologies must include in 6G are:

- Terahertz Communication
- Optical Wireless Communication Technology
- Wireless Power Transfer
- Artificial Intelligence

The major requirement of 6G wireless communication is the capability of handling massive data volumes and high data bit rate connectivity per device. This can be achieved by using the technologies and services mentioned above. A few of the key points trends behind the growth of the 6G wireless communications are green communication, intelligent network, localization, new spectrums, high reliability, low latency, high data bit rate, network availability.

Table.1. Comparison between 5G and 6G

Characteristics	5G	6G
Individual data rate	1Gbps	100Gbps
DL data rate	20Gbps	>1000Gbps
U-plane latency	0.5ms	<0.1ms
C-plane latency	10ms	<1ms
Mobility	500 km/h	1000 km/h
DL spectral efficiency	30 bps/Hz	100 bps/Hz
Operating frequency	3-300GHz	1000Ghz

1.3 Structure of the Paper

To better understand the article of review on 6G wireless communication technology, the structure of the paper is organized as follows; Chapter 2 introduces the literature review we have gone through. Chapter 3 presents the discussions on

topic 6G. Chapter 4 gives the conclusions and discusses the future scope. Finally, we have presented the references made.

2. Literature Reviews

In this survey, more than 20 publications in the field of underlying technology 5G and the emerging technology 6G have been referred from where many of the details regarding the working and the scope of the technology has been identified. Among them, a few have been described in this section. In 2018, Breandán Ó hAinle et al., [1] came up with a work that explains the devices and sensors applicable to 5G systems. In that work, the author tries to explain the working of some device technologies used in Analogue devices which are integrated 5G components. The paper explains the working of 3 different such components. In the same year, Nikolai Wolff et al., [2] came with another work that describes Switch-Type Modulators and Power Amplifiers for Efficient Transmitters in the 5G. The paper speaks about the working of envelope tracking solutions that can be used in future 5G base stations. It also discusses the significance of power amplifiers in 5G technology. In 2019, Ni Yunfeng et al., [3] came with research on concepts of 5G Network Technology. This paper explained the concepts, merits, and demerits of 5G. It also tried to address the large-scale antenna technology, full-spectrum access technology, and ultra-dense networking technology. In the same year, Yajun Zhao et al., [4] came up with research on 6G Mobile Communication Network: Vision, Challenges and Key Technologies where he addresses 6G vision with four concepts: Deep Connectivity, Ubiquitous Connectivity, Intelligent Connectivity, and Holographic Connectivity. The key technologies of 6G are presented in this paper along with technical requirements and challenges to realize the 6G vision which includes peak, connection everywhere, self-aggregating communications fabrics, and higher energy efficiency. In 2020, Wen Chiang [5] Chen studied 5G mmWAVE Technology Design Challenges and its Development Trends. This paper detailed the various design considerations and system specifications of RF architecture and beamforming of 5G mmWave systems. In 2020, another set of researchers Shan Liu et al., [6] done their work in Research on 5G technology based on the Internet

of things. This paper studies how the key technologies of 5G are utilized to develop the IOT and what are the latest developments in 5G technologies along with the possible outcomes. In the same year, Mostafa Zaman Chowdhury et al., [7] came up with work on 6G Wireless Communication Systems. The paper elaborates the requirements, technologies, challenges, applications, and research directions on 6G networks. Here the authors try to explain how the emerging technologies such as artificial intelligence, blockchain, three-dimensional networking, integration of wireless information and energy transfer, integration of sensing and communication, integration of access-backhaul networks, cell-free communications, dynamic network slicing, free space optic network, holographic beamforming, optical wireless technology, quantum communications, unmanned aerial vehicle, terahertz communications, and big data analytics can help the 6G architecture development. Other authors, Qianqian Pan et al., [8] studied Leveraging AI and Intelligent Reflecting Surface for Energy-Efficient Communication in 6G IOT. This work studied how intelligent reflecting surface (IRS) and artificial intelligence (AI) empowered energy-efficiency communication for 6G. In 2020, another work by IEEE fellow Ian F. Akyildiz et al., [9], published the future of wireless communication systems on 6G. The work also reviews the Internet of Bio-Nano Things, the Internet of Nano Things, and quantum communications.

3. Discussions

6th Generation of wireless communication technology is an upcoming future technology that is expected to be introduced in the 2030s. 6G technologies have to be implemented due to the highly increasing data traffic in our daily life. The main feature of 6G is to provide high speed data communication.

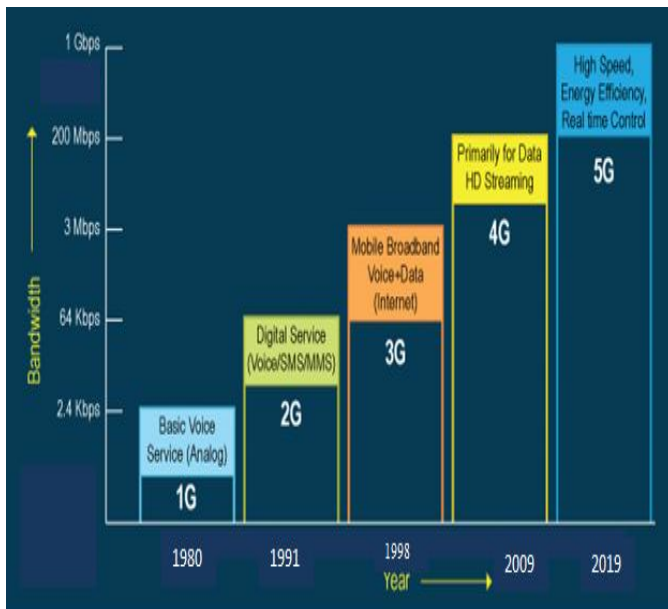
3.1 Evolutions of 6G.

Wireless communication will reduce the gap between users from everywhere in the world. 6G is a wireless technology used in mobile communications. G stands for generation in 6G. Each generation of wireless communication changes every ten years according to the trends. The wireless communication technology extends from 0G (0th Generation) to 6G (6th Generation).

Table. 2. (Generation of Wireless Technology)

Generation	Year	Features
0G	1970	Mobile radio telephonic systems were used for communication. That is one way communication is generated.
1G	1980	Systems provide roaming capability but the network feature is not available for use between countries.
2G	1991	Phone conversation, SMS, picture conversation.
3G	1998	3G provides wireless voice transmission, mobile internet access, video calls etc.
4G	2009	It provide all the features in 3G and also provide additional features like cloud computing, video conferencing, 3D television, IP telephony, gaming services, etc.
5G	2019	Multiple users can connect at a time. It reduces the latency rate from the previous generation of mobile communication.
6G	2030	It uses THz frequencies (Terahertz) and concept of artificial intelligence to make the communication more efficient.

Every generation of wireless technology brings new and exciting features. 6G wireless communication system was implemented to overcome the constraints of 5G for supporting new challenges and it will also continue the trends of the previous generations. The key drivers of 6G will be the convergence of all the past features, such as network densifications, high throughput, high reliability, low energy consumption, and massive connectivity. The most important requirement for 6G wireless networks is the capability of handling massive volumes of data, very high-data-rate connectivity per device, and ensuring high speed data transfer. For a better communication technology, 6G will replace gigahertz frequency (GBPS) from 5G to Terahertz frequency.



Graph 3.1.(Bandwidth of Previous Generations)

3.2 General Architecture of Wireless Technology

The communication between the entities (devices) doesn't generate directly from one entity (sender) to another (receiver). The data to be communicated is transferred to a server and then the particular data is transferred to the receiver from this private server of the network. Many technologies and concepts are used between these data transfers from a device to a server and vice versa. The general architecture representation of wireless communication technology is given below.

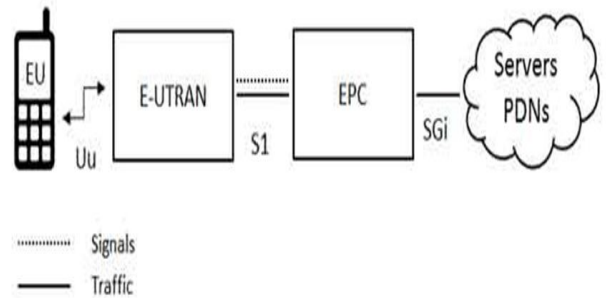


Fig.1.(Architecture of Wireless Communication)

The architecture of wireless technology contains 4 components.

- EU – Equipment of user
- EUTRAN Evolved UMTS Terrestrial Radio Access Network
- EPC Evolved Packet Core
- Servers PDNs – Servers Private Data Networks

The data sent from the sender (EU) breaks into packets and these packets reaches the server to store these data through EUTRAN and EPC.

3.2.1 Equipment of user

User equipment indicates any kind of device which is used by the user for wireless communication. An Each equipment of the user must contain 3 hardware components which are listed below.

- Mobile Terminal (MT): It is used to handle all the communication functions.
- Terminal Equipment (TE): It is used to terminate the data streams.
- Universal Integrated Circuit Card (UICC): UICC is also known as SIM cards. It runs an application which is used for storing the details of the user on a communication.

3.2.2 Evolved UMTS Terrestrial Radio Access Network

EUTRAN will control all the radio communication between the mobile and the packet core which is evolved in it. It acts as an intermediate between EU and EPC. It contains number of base stations (eNB-eNodeB). The data to be sent will reach the EPC by traveling through different base stations in EUTRAN from one place to another.

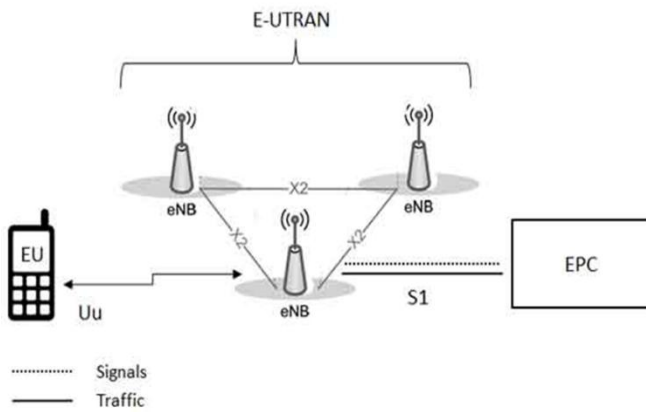


Fig.2. (Diagram of E-UTRAN)

3.2.3 Evolved Packet Core

EPC act as an intermediate between EUTRAN and the server for transmission of data. EPC contains 4 components and each component has its functions and they are illustrated below:

- The serving gateway (SGW) acts as a bridge to forward the data between the base station and the PDN gateway.
- The Packet Data Network Gateway (PGW) acts as a bridge to forward the data between the SGW and the server.
- The Home Subscriber Server (HSS) stores the information about all the network operator's subscribers.
- The Mobile Management Entity (MME) controls the high level operation of the entities by signaling messages and providing information to Home Subscriber Server (HSS).

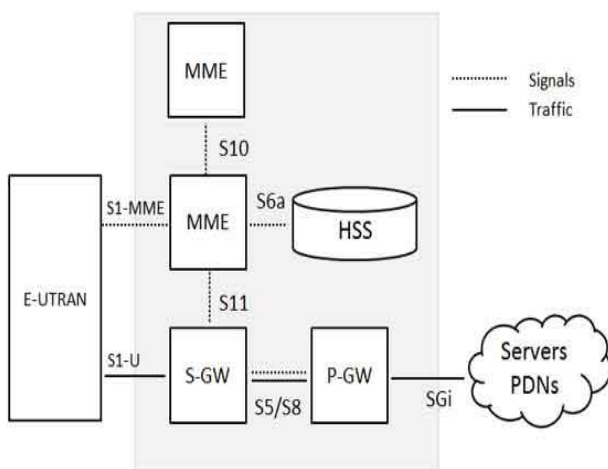


Fig.3. EPC diagram

3.2.4 Servers Private Data Networks.

Servers PDNs: It stands for Private Data Network Network’s Server. PDN server is used to store the data used by entities for the communication between them.

3.3 Technologies used in 6G.

Every generation of wireless communication technology uses different new technology concepts according to their trends. Likewise, 6G also differs in its technologies used from the previous generation. These technologies make 6G a proper future advanced generation of wireless communication technology. 6G uses mainly 4 concepts, they are Terahertz communication, Artificial intelligence, optical wireless communication and wireless power transfer.

3.3.1 Optical wireless communication

Optical wireless communication (OWC) uses visible light as the medium for the transmission of data. We know that light is the fastest medium in the world. So the OWC ensures high speed data transmission. The optical wireless communication will solve the data transfer rate issue which is raised in the 5G (previous generation). It also provides a low latency rate, long range communication, and secure communication.

3.3.2 Wireless Power Transfer

There are several base stations in Wireless technology for transferring the data for communication. The data packet is transferred from one base station (sender) to another (receiver), for that we need some kind of power has to be transferred. 6G uses the new concept of WIET (Wireless Information and Energy Transfer) for the transmission of data packets.

3.3.3 Terahertz communication

The 6th generation of wireless communication uses the terahertz frequency where the previous generation (5G) uses the Gigahertz frequency. The terahertz frequency contains its advantages. The terahertz frequency bandwidth ranges from 0.1THz to 10 THz. It ensures short range communication between two entities. It will play a crucial role in 6 G supplying more bandwidth, more capacity, ultrahigh data rates, and secure transmission.

3.3.4 Artificial Intelligence

The 6G will be the first generation to introduce the concept of Artificial Intelligence in Wireless communication technology. There arose many complex situations while establishing communication between entities. These complexities can be solved by those entities themselves by using the concept of Artificial Intelligence. Advancements in Artificial Intelligence will bring more intelligent networks for real time communications in 6G. The introduction of AI in 6G communication will improve and simplify the transmission of real time data.

3.4 Advantages

It supports a higher number of mobile connections than the 5G network which is about 10×10^5 per Km².

- 6G will optimize the healthcare sector by eliminating time and space barriers through remote surgery and ensures workflow optimization of health care.
- Mobile traffics are increasing indoors. To solve this issue 6G introduced DAS (Distributed Antenna System).
- 6G will allow real time access to the users instantly.
- 6G offers a very high data rate (Tb/sec) and very low latency (sub ms), so we can use 6G in many application areas of communication.

3.5 Challenges

We can't conclude that the 6G wireless communication contains disadvantages because it was not introduced yet. So we can conclude with some challenges which can be faced by 6G.

- 6G uses visible light frequencies (OWC) as a part of its communications. Hence drawbacks of visible light can be considered as drawbacks of 6G wireless technology. Visible light can cause damage to our naked eyes.
- Very large scale wireless communication technology has become an indispensable part of the world's energy consumption.
- It is very difficult to create an efficient design for wireless technology by managing a large number of terminals.

3.6 Current Scenario

The implementation of the 6G network has already started by launching a test satellite named long march 6 by china on November 6th, 2020. This satellite was named the world's 1st 6G satellite. This satellite ensures the terahertz frequency of communication for increasing the speed of a network. 6G wireless communications can be used in many areas like Extended Reality, Wireless Brain Computer Interaction, Connected Robotics, Haptic Communication, Automation and Manufacturing, and Internet of everything.

Conclusions and Future scope

This paper enrolls the development and review of the 6G wireless communication technology in the future according to many research works. The review was based on four main concepts or technologies (terahertz communication, optical wireless technology, wireless power transfer, and artificial intelligence) which are used to implement the 6G wireless communication system. Each generation of wireless communication technology brings new and exciting services. 6G wireless communication technology is an upcoming future technology that is expected to be introduced in the 2030s. It is very difficult to fulfill the requirement of the future generation in wireless communication due to the increase in network traffic in our daily life. The 6G have to be implemented to solve the requirements in the future communication process. The 6th generation also brings new features and benefits over 5G networks (previous generation). 6G provides improvements in areas like network availability, high reliability and low latency, high data bit rate, network availability, green communication, intelligent network, localization, and new spectrums. 6G technology will improve the performance and minimizes the energy consumption in wireless communication. 6G communication systems also ensure the trends of the future generation. The 6G wireless technology provides a better future communication system. The 6th Generation of wireless communication ensures more speed and encrypted communication according to the requirements in the future. 6G can be used in many areas like extended reality, wireless brain computer interaction, robotics and autonomous system, haptic communication, automation and manufacturing, Internet of

everything etc. 6G generates an optimized communication for these areas of technologies.

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